HAWAII'S TAPESTRY FORESTS

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(WITH SIX FIGURES)

Many of the Hawaiian mountains are deeply eroded. Torrential rainfalls, operating throughout vast periods of time, have strongly carved the original volcanic domes. Extraordinary precipices (called *pali* by the natives) abound in all parts of the islands. Fantastically sculptured canyons, ravines, and gorges, profusely cliffed and ramified, are characteristic of the montane areas. The valley walls are notably abrupt. Many of the valley heads are rimmed with cliffs and crags. The summit ridge on such islands as Kauai, Oahu, and Molokai is worn in many places to a thin crest, with numerous lateral "razorback" ridges.

Associated with this highly dissected topography is the subtropical montane rain forest. The general features of this forest have been presented by the writer in other papers.[1] Herein are described only those portions of the rain forest that cling to very steep slopes.

The naturalist, exploring the Hawaiian forests, is sure to be impressed by the ability of the groves to maintain themselves on very precipitous slopes. Although the individual trees are of small stature, with abundant shrubby undergrowth, all of the area is closely occupied, forming an unbroken arborescent or semi-arborescent mantle. The writer proposes the name "tapestry forest" for this particular forest type, that successfully occupies almost vertical mountain walls. All tapestry forest is montane rain forest, but all rain forest is not tapestry forest. Indeed, the most luxuriant rain forest is on gently sloping uplands (for example, Puna and Olaa, Hawaii); the trees of this *Metrosideros-Cibotium* formation attain heights of 75–90 ft. The tapestry groves of course do not grow on absolutely vertical cliffs. Seen from a

[1] Survey of the Hawaiian land flora. BOT. GAZ. **64**:98–114. 1917; Oahu rain forest. Amer. Forestry **23**:276–278. 1917; Economic woods of Hawaii. Forestry Quarterly **14**:696–716. 1916.

distance, the slopes mantled with vegetation appear to be much steeper than they actually are. The actual slopes range between 40 and 80°, averaging 50–60°. The vertical walls are either totally bare, or, if somewhat roughened and ledgy, support a depauperate, windswept, scattering growth of hardy grasses, ferns, and bryophytes. The moist areas, produced by seepage waters, are habitats of algae, lichens, and mosses.

The finest examples of tapestry forest occur in the following situations. On the island of Kauai: the Na Pali district, Wainiha,

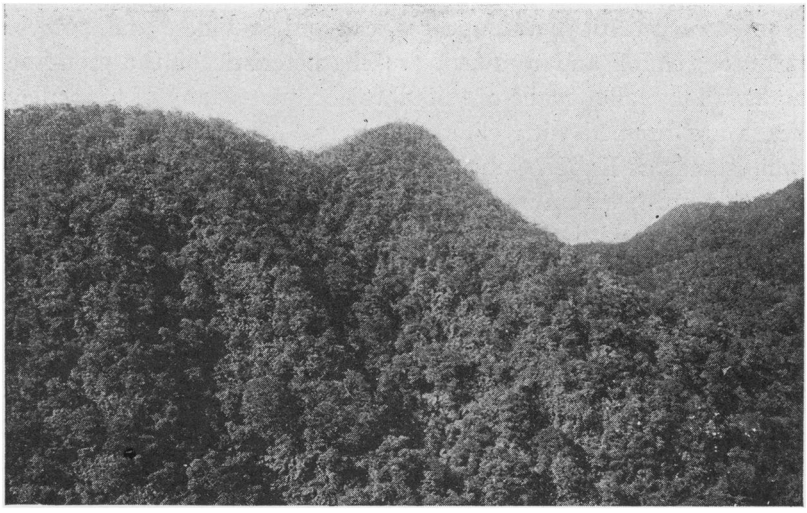

FIG. 1.—Tapestry forest on deeply eroded mountain ridges

Hanalei, and on the upper summit ridges and cliffs of Waialeale. On the island of Oahu: the windward precipices of the Koolau Range, and such valleys as Makaha, Makua, and Waianae, in the Waianae Range. On the island of Molokai: the precipices and summit slopes of such valleys as Halawa, Pelekunu, Wailau, and Kalawao. On the island of Maui: the valleys of Iao, Waikapu, Waihee, and the summit slopes of West Maui; also the windward and eastern valley slopes of East Maui. On the island of Hawaii: Waipio and Waimanu valleys, and other precipitous slopes along the Hamakua coast.

In altitudinal range the tapestry forests lie mostly between 800 and 4500 ft., in hygrophytic situations. In certain localities, as along the Hamakua coast, they extend to sea-level. In numerous situations along the Hawaiian coast are cliffs and low peaks, now arid and xerophytic, which give evidence of having been covered by tapestry rain forest in prehistoric times.

The steepness, wetness, and general inaccessibility of the tapestry groves have prevented wild cattle and goats from ravaging them. Thus they have been spared the devastations so

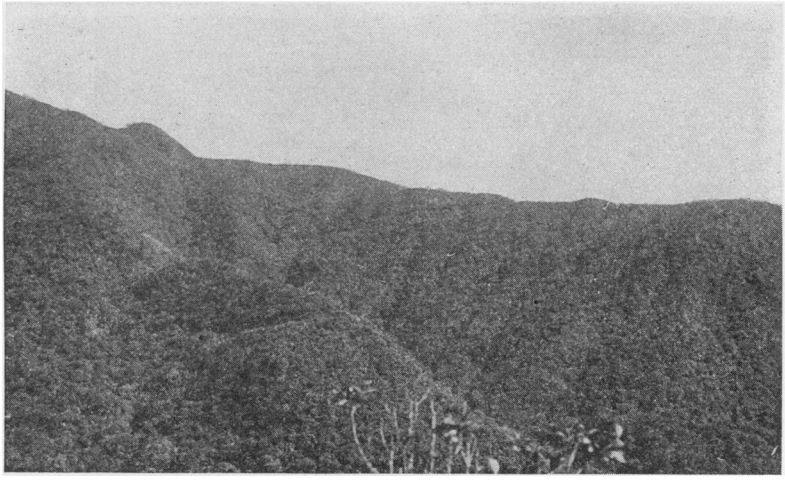

FIG. 2.—Oahu tapestry forest; montane rain forest

abundant and irreparable in the lower forests, and retain a much more primitive aspect. The undergrowth, although relatively scanty, and composed of smaller individuals than is the undergrowth of the lower forest, is particularly interesting because of its primitive and undisturbed character.

Closely related to the tapestry groves, both in ecological characters and in floral content, are the groves which inhabit the steep-walled hanging valleys, or high ravines, that are such a characteristic feature of the Hawaiian montane topography. These steep glens, lying at elevations of 800–3000 ft., do not terminate on the level of the valley floor into which their waters debouch, but on the face of

sheer cliffs, 100–2000 ft. high. The streams fall over these cliffs in beautiful cascades. The rain forest in the hanging valleys is not subjected to ecological conditions as severe as those of the tapestry forest, and hence attains more normal development.

The tapestry groves are notably dwarfed, with the aspect of marked and premature senility. The conditions of the substratum

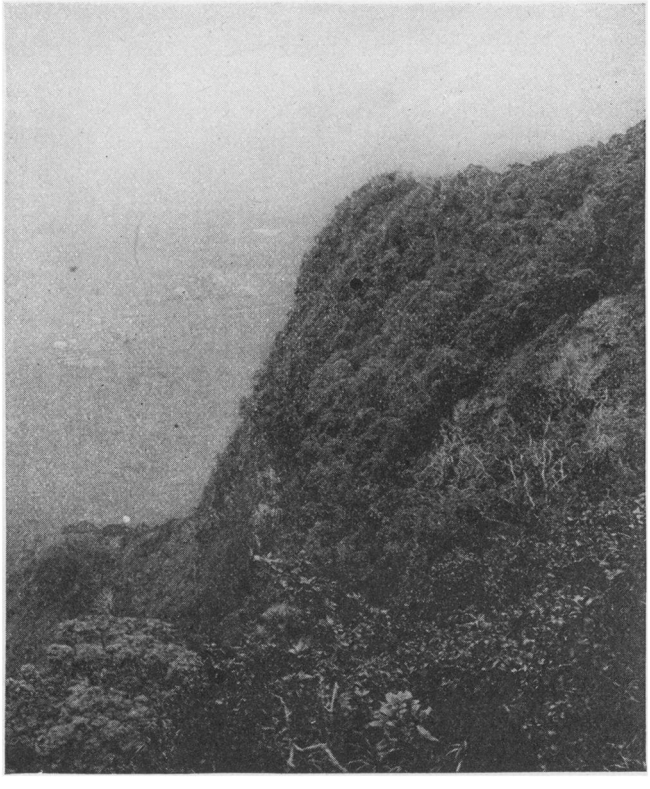

FIG. 3.—Tapestry groves on very steep lateral spurs

afford but precarious roothold, and are obviously unfavorable for normal arborescent development. Many species that in sheltered level regions reach heights of 50–80 ft., with large trunks and symmetrical crowns, are stunted, gnarled, and dwarfed to a marked degree on the precipices. The trunk is short, usually leaning outward from the cliff, rarely erect, and breaks up into a number of

wind-shaped branches. Most of the steep slopes are subjected to strong winds, which impress their mark upon all aerial parts of the vegetation. Very young trees and old dead trees are alike rare in the tapestry groves, the area being so closely occupied by mature trees. Conditions are unfavorable for seedlings, and reproduction is conspicuously retarded. Weakened or dead trees soon lose their roothold, and fall from the grove into the lowlands below. The appearance of senility is in part fictitious, as none of the trees give

FIG. 4.—Tapestry groves on valley wall, Kalihi, Oahu

evidence of being more than 100–150 years old, and the younger trees (10–50 years) soon acquire an aged and decrepit appearance in their ceaseless struggle against gravity and wind.

The observer, standing on the floor of a valley and looking at the forest mantle which drapes the slopes, is impressed by the various shades of green in the mottled canopy. All of the tree crowns are domed or hemispherical; there are no conifers or cycads. Most of the crowns are more or less highly ramified. The foliage in the majority of cases is composed of small, simple, oval, glossy

leaves. Thus the summits or crowns of the various species look very much alike, save for the differences in the green tints. These

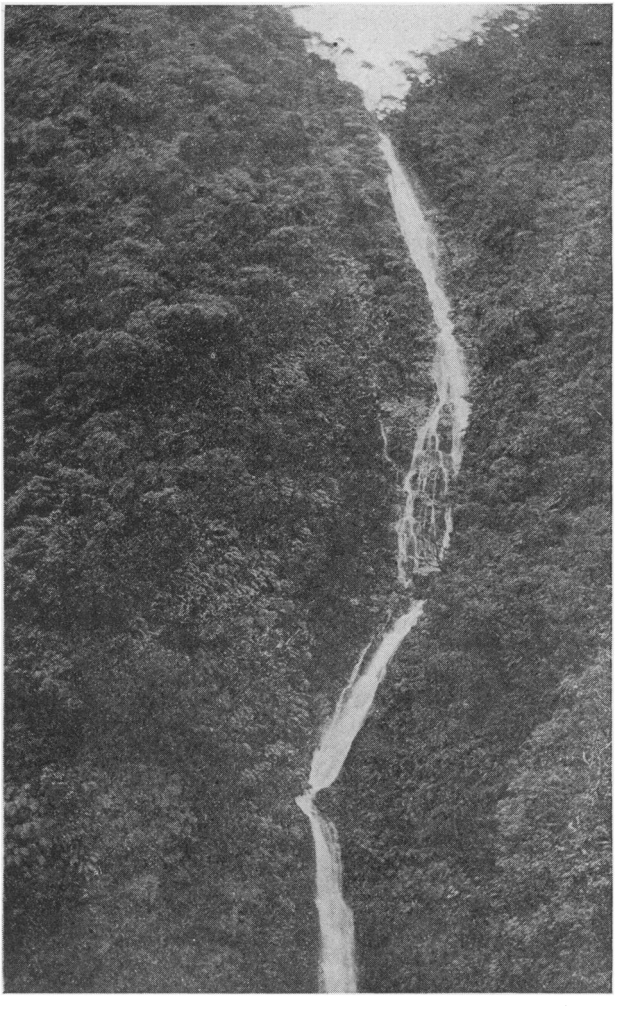

FIG. 5.—Vertical wall, with cascade and tapestry formation

differences are much more pronounced than in temperate zone forests, and give to the tapestry a distinctive and singular charm. Gray-green, yellow-green, olive-green, silver-green, green flushed

with red, heavy somber green, glossy green, literally scores of subtle and indefinable shades of green are discernible to the prac-

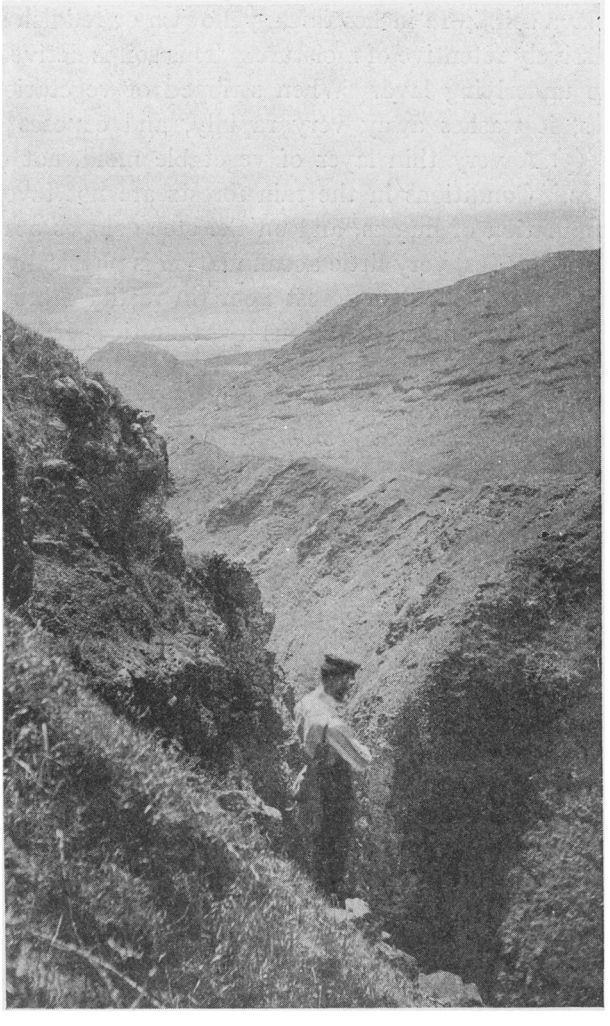

FIG. 6.—Arid ridges and precipices, formerly forested, devastated by goats and cattle

ticed eye. These varied hues give to the groves, particularly in the slant light of late afternoon, a rich, mottled, velvety effect, as though the forest were indeed a wondrous woven drapery.

A vertical or cross-section through a typical grove would reveal the following strata. (1) The basaltic rock cliff or wall, made up solely of ancient lava beds, piled one upon another. (2) A thin layer of lava soil, 4–12 inches thick, yellowish or reddish stiff clay, and excessively retentive of moisture. This soil is derived directly from the underlying lava. When stripped of vegetation, as by landslides, it washes away very rapidly, and exposes the rock strata. (3) A very thin layer of vegetable mold, not exceeding 2–6 inches. Conditions in the rain forests are not favorable for the accumulation of humus, and on the steep slopes occupied by the tapestry groves, very little accumulation is physically possible. (4) The vegetable mold or forest floor (in reality more of a wall than a floor) is covered with various hygrophytic species of lichens, liverworts, mosses, filmy ferns, coarser ferns, and a few herbaceous-perennial seed plants. Among the latter are such genera as *Astelia*, *Cunnera*, *Liparis*, *Peperomia*, *Nertera*, etc. (5) The forest proper, consisting of small trees, shrubby trees, shrubs, and lianas. The following are representative members of the Hawaiian tapestry grove formations:

Acacia koa Gray
Aleurites moluccana Willd.
Alyxia olivaeformis Gray
Antidesma platyphyllum Mann
Bobea elatior Gray
Broussaissia arguta Gaud.
Charpentiera ovata Gaud.
Cheirodendron Gaudichaudii Seem.
Cheirodendron platyphyllum Seem.
Claoxylon sandwicense Mueller
Clermontia spp.
Coprosma spp.
Coreopsis spp.
Delissea spp.
Dodonaea viscosa L.
Dubautia laxa Hook. and Arn.
Dubautia plantaginea Gaud.
Elaeocarpus bifidus Hook. and Arn.
Eugenia sandwicensis Gray
Euphorbia Hookeri Steud.
Euphorbia multiformis Hook. and Arn.
Euphorbia spp.
Eurya sandwicensis Gray
Exocarpus brachystachys Hbd.
Freycinetia Arnotti Gaud.
Gardenia Brighamii Mann
Gardenia Remyi Mann
Gouldia spp.
Hesperomannia arborescens Gray
Hibiscus Arnottianus Gray
Hibiscus kokio Hbd.
Ilex sandwicensis Loes.
Kadua spp.
Labordia spp.
Lipochaeta connata DC.
Lipochaeta decurrens Hbd.
Lipochaeta spp. and vars.
Lobelia spp.
Lysimachia Hillebrandia Hook. f.
Lysimachia spp.
Maba sandwicensis A.DC.
Metrosideros macropus Hook. and Arn.
Metrosideros polymorpha Gaud.

Metrosideros rugosa Gray
Metrosideros tremuloides Rock
Nothocestrum spp.
Ochrosia sandwicensis Gray
Osmanthus sandwicensis Knobl.
Osteomeles anthyllidifolia Lindl.
Pelea spp.
Perrottetia sandwicensis Gray
Phyllostegia spp.
Pipturus albidus Gray
Pisonia umbellifera Seem.
Pittosporum spp.
Plectronia odorata Benth. and Hook.
Platydesma campanulata Mann
Platydesma cornuta Hbd.
Pritchardia spp.
Rauwolfia sandwicensis A.DC.
Reynoldia sandwicensis Gray
Rollandia spp.
Santalum Freycinetianum Gaud.
Santalum spp.
Scaevola spp.
Scheidea spp.
Sideroxylon spp.
Smilax sandwicensis Kunth.
Solanum sandwicense Hook. and Arn.
Stenogyne spp.
Straussia spp.
Styphelia tameiameia F. Muell.
Suttonia spp.
Tetramolopium spp.
Tetraplasandra spp.
Urera sandwicensis Wedd.
Vaccinium penduliflorum Gaud.
Viola spp.
Viscum articulatum Burm. and vars.
Wikstroemia spp.
Xanthoxylum spp.

Among the ferns of the humid forests, the following are likely to occur in the tapestry groves:

Adiantum capillus-veneris L.
Asplenium spp.
Athyrium spp.
Botrychium subbifoliatum Brack.
Ceropteris spp.
Cibotium Chamissoi Kaulf.
Cibotium Menziesii Hook.
Cibotium glaucum Hook. and Arn.
Coniogramme spp.
Cyrtomium Boydiae Robins.
Dicranopteris spp.
Diellia pumila Brack.
Diellia falcata Brack.
Doodia Kunthiana Gaud.
Doryopteris spp.
Dryopteris spp.
Elaphoglossum spp.
Filix Douglassii Robins.
Hymenophyllum spp.
Hypolepis punctata Mett.
Lycopodium spp.
Marattia Douglassii Baker
Microlepis spp.
Neottopteris Nidus J. Sm.
Odontoloma Macraeanum Brack.
Ophioglossum pendulum L.
Pellaea ternifolia Link.
Phymatodes spp.
Polypodium spp.
Psilotum complanatum Sw.
Psilotum nudum Griseb.
Ptedium aquilinum Kuhn
Pteris cretica L.
Sadleria cyatheoides Kaulf.
Sadleria Hillebrandii Robins.
Sadleria polystichoides Heller
Sadleria spp.
Schizaea robusta Baker
Selaginella spp.
Tectaria cicutaria Robins.
Trichomanes spp.
Vittaria rigida Kaulf.

Of particular interest, from the ecological viewpoint, are the root systems of the tapestry grove trees and shrubs. The combination of steep declivity, thin clay soil, and rock substratum necessitates the development of an unusually strong mechanical root-supporting system. Most of the trees have a number (5–12) of large proplike roots which extend downward below the trees, and are firmly rooted in interstices in the ancient lava beds. These lower roots brace the tree staunchly from below. On the upper side of the trunk are usually several long anchoring roots, more or less exposed in the thin vegetable mold. The extremities of these roots are likewise rooted among the rock strata. In some situations, where the processes of erosion are gaining upon the grove, and have washed away much of the grove floor, the intricate systems of anchoring and bracing roots are beautifully displayed. On many cliffs and steep ridges these strong roots form a sort of natural ladder, well known to the natives and woodsmen, who utilize them in ascending or descending the slopes. In many situations ascent would be well-nigh impossible were it not for these tough, firmly anchored, exposed roots.

Lianas of various species establish themselves in the tapestry groves, and in some places become so luxuriant as to form almost impenetrable hanging jungles. Conspicuous among these vines are species of *Freycinetia*, *Dicranopteris*, *Smilax*, *Dioscorea*, *Alyxia*, *Ipomoea*, *Convolvulus*, etc. The liana formations are best developed at the lower levels; above 2000 ft. the groves are practically free from vines, which are replaced by the dense soggy moss formations.

The tapestry groves, owing to the hygrophytic environment, are usually heavily clad with thick layers of epiphytic lichens, mosses, filmy ferns, and liverworts. These layers, on the smaller branches and saplings, are often 4–8 inches in radius. The outer layer alone is green and living; the under layers, of dead vegetable material, are saturated with rain water, and may be wrung out like a wet sponge. This moss covering is best developed at the higher altitudes (1800–4000 ft.), where the annual precipitation is 100–400 inches. These upper tapestry groves are swathed in fog and rain during most of the year, and comprise a range of woody species different from that of the lower groves.

Landslides are perpetual enemies of the hanging groves. They cut short the lives of the trees which they undermine, and expose fresh rock surfaces to soil-making and revegetation. The landslides vary in width from 6 to 60 ft., and in length from 25 to 1000 ft. Owing to the slow rate of reproduction in the rain forest species, and the inhospitable climatic and soil conditions for seedlings, these rents in the tapestry are slow healing. Commonly various grasses and such ferns as *Dicranopteris* and *Sadleria* are the first invaders, followed by herbaceous-perennial seed plants (*Dianella*, *Coreopsis*) and shrubs. The arborescent species come last, and very slowly.

The two great activities of subsidence and erosion are gradually but inexorably reducing the areas occupied by the tapestry groves. The base-leveling action of erosion tends to flatten all slopes. The immeasurably slow subsidence of the entire archipelago has shrunk the original heights of the mountains. Thus, from the historical viewpoint, tapestry groves represent a transient ecological phenomena. At present it is possible to find every stage, from steep walls covered with luxuriant endemic woody tapestry, to flattened earthy hills, clad only with foreign grasses, and ranged by cattle.

The tapestry groves are of large economic value as earth protectors and water conservators. Their scenic beauty alone would amply warrant their stringent protection. As water sheds they are of much local significance. They comprise one of Hawaii's most distinctive and lovely natural assets.

HONOLULU, HAWAII